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Case study in Nipissing Forest, Ontario

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Abstract

Stand attributes estimated from forest resource inventory (FRI) were validated using field data collected in 136 stands in Nipissing Forest (Ontario, Canada). The results showed 39% agreement between classification of stands into standard forest units (SFU) based on comparing FRI- and field-estimated species composition. Stand age, height, and stocking were compared separately for groups of stands representing seven standard forest units, classified based on FRI species composition. The FRI-based stand age was on average 20 years greater than that estimated in the field for three of the standard forest units compared but no significant difference between FRI- and field-based age was found for four other standard forest units. The mean difference between FRI- and field-based stand height was significantly different from zero for all tested standard forest units; on average the FRI-based height was 1.37 m lower for four standard forest units and 1.64 m higher for three standard forest units. No significant difference in stand stocking was detected for six of the standard forest units while for the seventh the FRI-based stocking was on average 0.3 lower than respective field estimates.

This study provides baseline data that may be used (with additional information if needed) as adjustment factors for FRI-based stand attributes, as a template for other FRI validation studies, and as a basis to recommend that a new inventory be conducted and/or to prioritize re-inventory activities. The methods can also be adopted to document and improve the accuracy of FRI data for all forest management units in Ontario.

Résumé

Les estimations relatives aux caractéristiques de peuplement provenant d'un inventaire des ressources forestières (IRF) ont été validées grâce aux données de terrain recueillies dans 136 peuplements de la forêt Nipissing (Ontario, Canada). Cette validation a montré une correspondance de 39 % dans la classification des peuplements des unités forestières normalisées (UFN) par rapport à la composition des essences estimées de l'IRF et sur le terrain. L'âge, la taille et la densité relative des groupes de peuplements représentant sept unités forestières normalisées et classifiées en fonction de la composition des essences de l'IFR ont été comparés séparément. Par rapport à l'IFR, la moyenne d'âge du peuplement est de 20 ans supérieure à celle estimée sur le terrain pour trois des unités forestières normalisées comparées. En ce qui concerne quatre autres unités, aucune différence d'âge importante n'a été relevée. La différence moyenne entre la hauteur du peuplement de l'IFR et celle des peuplements sur le terrain était assez éloignée de zéro pour toutes les unités forestières normalisées examinées. En moyenne, la hauteur selon l'IRF était inférieure de 1,37 m dans quatre unités et supérieure de 1,64 m dans les trois autres. Aucune différence notable n'a été relevée dans la densité relative de six des unités forestières normalisées tandis que dans la septième, la densité relative selon l'IFR était inférieure de 0,3 en moyenne aux estimés correspondants effectués sur le terrain.

Cette étude fournit des données de référence qui peuvent être utilisées (en parallèle à d'autres renseignements, au besoin) comme éléments correcteurs des caractéristiques des peuplements de l'IFR, en tant que modèle pour d'autres études de validation d'IFR, comme base de recommandation pour la réalisation d'un nouvel inventaire ou encore pour établir la priorité des mesures liées au nouvel inventaire. Les méthodes peuvent également être adoptées pour documenter et améliorer la précision des données de l'IFR pour toutes les unités de gestion de la forêt de l'Ontario.

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Introduction

Ontario forests cover approximately 71 million hectares and represent about 17% of Canada's forested land (OMNR 2006). Forest management in Ontario occurs in the Area of Undertaking (AOU), a band between approximately 45° and 51° N that covers approximately 44 million hectares, 36 million hectares of which are forested (Fig. 1). The boundaries of the AOU represent the northern limit of current commercial timber operations and the southern limit of large contiguous forests on Crown Land. For forest management purposes the AOU is divided into administrative units (forest management units or FMUs). These range from approximately 122,000 to 1.6 million hectares and in forest type from hardwood-dominated forests of the Great Lakes–St. Lawrence forest region to the conifer-mixedwood boreal forest region.

The main information base for forest management planning in Ontario is the Forest Resource Inventory (FRI). In general, a forest resource inventory may be defined as a survey of an area to provide information on the present extent, composition, structure and location of the forest (Gillis and Leckie 1993). In Ontario, the FRI is conducted on a cycle of approximately 20 years. The primary data sources for FRI production are aerial photographs taken at 1:20,000 for northern Ontario and 1:10,000 for southern Ontario. These photographs are interpreted to delineate forest stands and assess stand attributes using calibration timber cruise plots established subjectively in stands representing either typical forest conditions or areas of uncertainty. If available, other sources of information (such as history of harvesting, recent disturbances) may assist photo interpretation. The interpreted stand boundaries and attribute data are later transferred onto maps to produce FRI for a given area.

Stand attributes in the Ontario FRI include tree species composition, age, height, stocking, and site class (Gillis and Leckie 1993). Tree species composition describes the most common tree species in a stand, tree species are listed in descending order of percentage of crown occupancy. Species content is given to the nearest 10% and all species contributing at least 10% to the canopy of the stand are listed. Stand age (to the nearest 5-year class) and height (to the nearest 1 m) are estimated for the dominant tree species or group of similar species (e.g., black spruce (*Picea mariana* (Mill.) B.S.P.) and white spruce (*Picea glauca* (Moench) Voss) may be grouped together), defined as the species or group of species with the greatest estimated basal area in the stand. Site class is a derived attribute (expressed on a 5-class scale) determined from the age to height relationship defined in normal yield tables (Plonski 1981). Finally, stocking is defined as the stand basal area relative to the normal basal area (from normal yield tables) for the appropriate species, age, and site class. Stocking is interpreted directly from the photographs by relating canopy cover to stocking values calculated in calibration plots. Stand attributes that form the FRI are the basis of large-scale forest management planning in Ontario and are used to estimate and predict timber and wildlife habitat supply and to predict successional changes throughout natural or management-induced stand development.

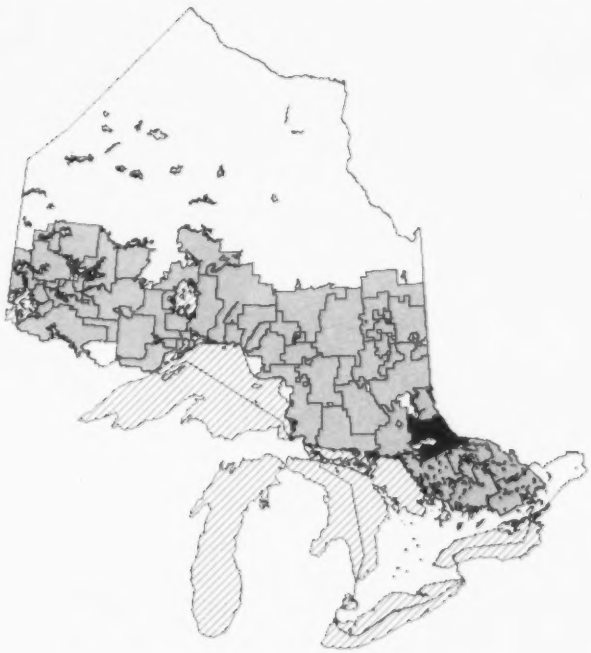

Figure 1. *Ontario's forest management units (shaded) highlighting location of Nipissing Forest (in black).*

The quality of a forest resource inventory is crucial for assessing current forest condition and future management planning. For example, an analysis of timber supply predictions in Quebec has shown that most sources of uncertainty were related to the forest resource inventory (MRNFP 2004). In Ontario, forestry specialists from several organizations including MNR and forest industry classified the FRI as one of the main sources of uncertainty in timber supply prediction (Sobze et al. 2006). Errors in the FRI-based information may propagate through planning tools (such as timber supply models) and result in predicted forest conditions substantially different from the actual ones. Such errors may occur due to for example, incorrect photo interpretation, insufficient sampling of plots used to calibrate the aerial photos, inaccurate application of formulae or look-up tables used to derive some of the stand attributes (e.g., height, site class), or infrequent and untimely FRI update.

In this report, we present the methods and results of a case study to validate FRI-produced stand attributes for one of Ontario's forest management units, Nipissing Forest. More specifically, the report includes:

a) methods used to validate stand attributes,

b) results of evaluation of agreement between field- and FRI-based stand attributes (age, height, stocking, and species composition), and

c) recommendations for future studies on FRI validation.

Materials and methods

The study was conducted in the Nipissing Forest Management Unit (FMU) located in the Great Lakes-St. Lawrence region of Ontario`s managed forest area (Figure 1). The FMU is just over 1 million hectares including forested area, water, and other non-forest area. Of that, approximately 602,850 ha are classified as Crown productive forest available for timber production (Cottam and Street 2004). Dominant species include trembling aspen (*Populus tremuloides* Michx.), sugar maple (*Acer saccharum* Marsh.), eastern white pine (*Pinus strobus* L.), white birch (*Betula papyrifera* Marsh.), black spruce, jack pine (*Pinus banksiana* Lamb.), and red pine (*Pinus resinosa* Ait.).

The most recent forest inventory for this FMU was based upon 1989 photography. Descriptive statistics for the FMU, including proportion of area in *standard forest units* are provided in Appendix 1. Standard forest units are part of a regionally developed classification system that aggregates forest stands for the purpose of forest modelling and management purposes. Forest stands within a standard forest unit will have similar forest composition, develop in a similar manner (both naturally and in response to silvicultural treatments), and will be managed under the same silvicultural system (OMNR 2004). Assignment of stands to standard forest units is based on a set of region-specific rules that specify minimum species' content for each unit; for some units, the rules also include minimum requirements for stand age, stocking, and site class. A complete set of rules defining standard forest units for Nipissing Forest is provided in Appendix 2.

Data collection for this study occurred in summer 2003. Field-based information was obtained by sampling stands using stratified sampling to represent major forest types (hardwood, mixedwood, mixed conifer) that had not had management activities in the previous 20 years and were located within 1.5 km of a road. A total of 136 stands were selected. Within each stand, a cruise line was established by randomly selecting the line's starting point and direction. Ten stations were established along the cruise lines approximately 20 m apart. At each station, all trees taller than 2 m were counted using a 2 BAF wedge prism. Additional attributes (height and age) were sampled at three non-adjacent stations (e.g., stations #2, 5, and 8); at each station, three to four dominant or co-dominant trees of major tree species were measured for height using a Vertex® and stem age-increment core was taken at 30 cm above the ground.

For each sampled stand, species composition was calculated by averaging tree basal area from the 10 stations. Height and age were calculated by averaging among all sampled trees within the 10 stations. Stocking was calculated by dividing basal area (averaged for the 10 stations) by basal area from normal yield tables for dominant species (Plonski 1981).

FRI-based attributes (age, height, stocking, and species composition) for the sampled stands were retrieved from the FRI for Nipissing FMU. Each sampled stand was assigned to a standard forest unit based on species composition (1) estimated in the field and (2) retrieved from the FRI, using forest unit rules presented in Appendix 2. Hereafter, these forest unit assignments are referred to as field- and FRI-based, respectively. Comparison of field- and FRI-based stand classification was conducted using a count of classified stands in each of the forest units.

To compare tree species composition, a "minimum difference" between the two forest unit classifications was estimated for each sampled stand. The minimum difference was estimated as the minimum change in FRI-based species composition required for a stand to be classified into the same forest unit as it was in the field data. For example, the minimum difference between a stand with the FRI-based species composition Mr6Bw2Po1Bf1 and the field-based standard forest unit BW1 (defined by a condition Bw+Po ≥ 5, see Appendix 1) is equal to 2 (for species codes see footnote to the table in Appendix 1). In other words, the cumulative proportion of white birch (Bw) and poplar (Po) in the FRI-based species composition needs to be increased by 20% to meet the condition of forest unit BW1; hence, the minimum difference between FRI- and field-based classifications for this stand is equal to 20%.

To compare other stand attributes with the field measurements, the FRI-based age and height were "updated" to the year of field data collection following the same procedure usually used in updating FRI for forest management planning. For each sampled stand, the FRI-based stand age was increased by 14 years - the length of period between the year of FRI photography (1989) and the year of field measurements (2003). Stand height was updated using site index curves for the stand's dominant species. Since FRI only contained information on site class (not site index), the difference between actual stand height and average height for a respective site class was calculated at the FRI-based stand age, and the latter difference was added to the average height for the site class at the "updated" FRI-based stand age.

The updated attributes were used in the analysis. Throughout the rest of this text they are referred to as FRI-based height and age. FRI-based stocking was not changed and was compared directly with field-based estimates of stocking. The analysis was performed on FRI-based standard forest units, i.e., the data were divided into groups by stand assignment to standard forest unit based on FRI species composition. The ultimate objective of the analysis was to test whether there were statistically significant differences between FRI- and field-based stand age, height, and stocking, and where different, to test whether standard forest units can be pooled into groups, with FRI- and field-based stand attributes that are significantly different among groups but insignificantly different within groups. For each analyzed attribute, the following steps were taken:

1. Field-based attributes were regressed on FRI-based attributes to test for a systematic pattern in the difference between attributes for each stand (e.g., the difference between FRI- and field-based stand age increases as the FRI-based stand age increases).
2. Difference between FRI- and field-based attributes was tested for normality (by standard forest unit) and homogeneity of variance (among standard forest units).
3. Mean difference between FRI- and field-based attributes was tested for significance of difference among standard forest units using one-factor ANOVA.
4. Mean difference between FRI- and field-based attributes was tested for significance of difference among standard forest units using Neuman-Keuls test for multiple comparisons among the means.
5. If needed, Scheffé's multiple contrasts test was used to test the standard forest unit groups for which Neuman-Keuls test yielded ambiguous results.
6. Data for standard forest units that were not significantly different (based on the results of testing in steps 4 and 5) were pooled together, and for each of the pooled groups the mean difference between FRI- and field-based attributes was tested for significance of difference from zero using a one-sample *t*-test.

Table 1. *Comparison of FRI- and field-based classification of 136 stands in standard forest units. An individual cell (row I, column J) contains the number of stands classified as forest unit I in FRI and as forest unit J in the field. The numbers of identically classified stands are shown in bold.*

FRI-based forest units[a]	Field-based forest units																							Number of stands
	BW1	BY1	CE1	LC1	LWMW	MHBE	MHCON	MW1	MW2	MW3	OAK	PJ1	PO1	PR1	PWST	PWUS4	PWUSC	PWUSH	SB1	SF1	SF2	SP1	THSL1	THSL2	
BW1	**9**	0	0	0	0	0	0	0	1	3	0	0	1	0	0	1	2	0	0	0	0	0	0	0	17
BY1	1	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
CE1	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	3
LC1	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LWMW	0	0	0	0	**0**	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MHBE	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4
MW2	1	0	0	0	1	0	0	0	**3**	1	0	0	0	0	0	0	0	0	0	1	2	0	0	1	10
MW3	0	1	0	0	0	0	1	0	5	**1**	1	0	0	0	0	0	1	0	0	0	0	0	0	0	10
PJ1	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	1
PJ2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2
PO1	3	0	0	0	0	0	0	0	1	0	0	0	**3**	0	3	1	1	1	0	0	1	0	0	0	14
PR1	0	0	0	0	0	0	0	0	0	0	0	0	1	**2**	0	0	2	0	0	0	0	0	0	0	5
PWOR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
PWST	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	3	1	0	0	0	0	0	0	0	6
PWUS4	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	**3**	1	0	0	0	0	0	0	0	6
PWUSC	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	1	**5**	0	0	0	0	1	0	0	10
SB1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**	1	0	0	0	0	4
SF1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**6**	2	0	0	0	11
SF2	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0	0	**3**	0	0	0	7
SP1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	**0**	0	0	2
THSL1	0	0	0	0	0	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**	1	6
THSL2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	**9**	13
THUSP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1

[a] forest units not represented by any stands are not listed

7. For each group of standard units (pooled based on the results of steps 4 and 5), confidence intervals (at 95% level) were estimated for the mean difference between FRI- and field- based attributes.

The analysis was performed using the statistical package SYSTAT 11 (SYSTAT Inc. 2004). Some of the statistics not included in SYSTAT were calculated in MS Excel using formulae from Zar (1996). Details on the analytical steps are provided in Appendix 3.

Results

The results of comparison between FRI- and field-based forest unit classification based on tree species composition are presented in Table 1. Column and row headers in Table 1 list FRI- and field-based standard forest units, respectively. A cell (row *I*, column *J*) includes the number of stands classified as forest unit *I* in the FRI that were classified as forest unit *J* in the field data; the numbers of stands for which FRI- and field-based classification of forest units matched are in bold font. The last column shows the total number of sampled stands classified in FRI as forest unit *I*.

Figure 2 illustrates the proportion of sampled stands that require minimal change in FRI-based species composition to be classified into the same forest unit as in the field data. As seen from Figure 2, a 10%, 20%, and 30% change in FRI-based species composition would increase to 65%, 79%, and 91%, respectively, the total proportion of stands classified to the same forest unit. Two points are the key to understanding these results. First, they are based not on an arbitrary or most probable change but on a directed "minimum" change required for the stand to be classified into the same unit. Second, they account only for a stand's species composition, while for actual classification other stand attributes (age, stocking, and site class) are considered. For example, a stand may have the species composition meeting a description of standard forest unit A but be assigned to standard forest unit B because its age, stocking, or site class do not meet requirements of unit A. In calculations on which Figure 2 is based, this stand would be included in the proportion of stands corresponding to zero minimum difference in species composition (striped bars). For this reason, this fraction (46%) is higher than the one calculated from Table 1.

Once the stands surveyed were classified into standard forests units, sample sizes were very uneven, with the number of sampled stands per FRI-based forest unit ranging from 1 to 17; seven FRI-

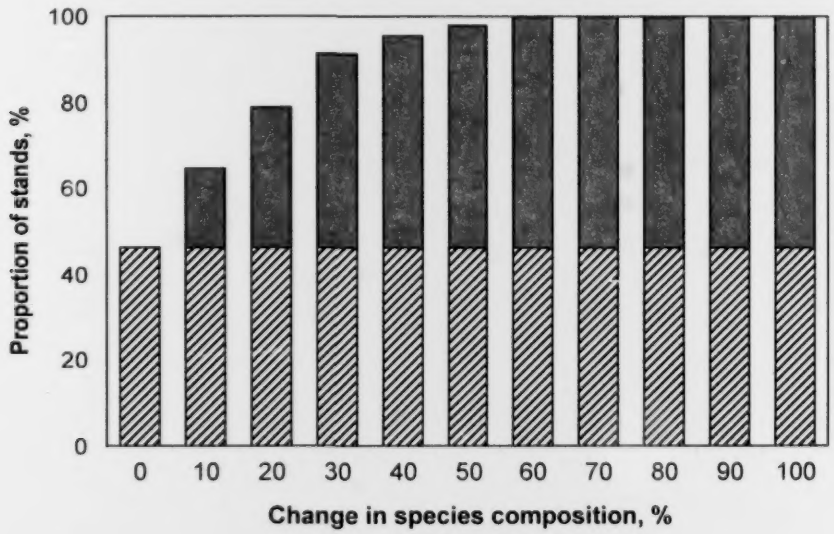

Figure 2. *Proportion of stands classified into the same standard forest unit using FRI and field data. Diagonal-striped bars show those for which FRI- and field-based forest units match; shaded bars show additional proportion of stands for which FRI- and field-based forest units would match with minimum change in FRI-based species composition.*

based forest units were not represented at all (Table 1). This uneven sample size resulted from stratification of Nipissing Forest for field sampling, which was based on planning forest units (which are slightly more aggregated due to local management considerations) grouped to reduce the number of strata. For example, forest management planners combined PO1 and BW1 (poplar and white birch) in one group, MHBE, MHCON, THSL1, THSL2, MIDHD, OAK, THUSP, and THUSG (hardwood selection and hardwood uniform shelterwood) in another group, etc. The analysis, however, was based on standard forest units, which resulted in the varying sample size reflected in Table 1.

The FRI-based standard forest units with a minimum sample size of 10 or more stands included BW1, MW2, MW3, PO1, PWUSC, SF1, THSL2 (codes and classification rules presented in Appendix 2); these units account for 49% of productive forest in the Nipissing Forest (Appendix 1). These units were included in the analysis of other stand attributes (age, height, and stocking); the sample size for other units was too small for valid statistical conclusions. Descriptive statistics for the seven above-listed forest units are presented in Table 2.

Figure 3 shows the overall agreement between FRI- and field-based attributes. Each symbol represents an individual stand, while the diagonal line shows where FRI- and field-based attributes equate. Here we provide only the overall results of the analysis; more details are presented in Appendix 3.

For each attribute, the analysis separated the seven standard forest units into two groups. The mean difference between FRI- and field-based attributes was not significantly different within each group of standard forest units but was significantly different among the groups. The grouping of forest units for each attribute and the mean difference between FRI- and field-based attributes for each group along with a 95% confidence interval are presented in Table 3 and Figure 4; the mean difference and respective confidence interval boundaries are rounded to the same decimal place as in the original FRI and field data. For example, the grouping for stand height shows that all stands were divided into two groups. The first group included stands classified into one of the standard units – BW1, PO1, PWUSC, SF1 – based on the FRI species composition; similarly, the second group included stands classified into MW2, MW3, or THSL2. The

Table 2. *Descriptive statistics for seven FRI-based standard forest units included in the analysis of age, height, and stocking. For each attribute, the difference was calculated as the field-based value subtracted from the FRI-based value of the attribute for the same stand. Each cell contains the mean and the range of values of the attribute from the FRI.*

Attribute	FRI-based forest unit						
	BW1	MW2	MW3	PO1	PWUSC	SF1	THSL2
Number of stands	17	9[a]	10	14	10	11	12
FRI-based age (year)	76.06 55 – 85	69.78 57 – 95	86.80 55 – 155	65.50 24 – 98	59.70 40 – 100	91.46 57 – 135	72.17 55 – 154
Age difference (year)	3.77 -19 – 26	18.44 -21 – 42	23.60 -2 – 60	-0.57 -28 – 31	2.70 -21 – 44	18.73 -16 – 55	-3.17 -21 – 60
FRI-based height (m)	20.06 18.2 – 25.2	17.04 15.0 – 20.4	19.02 14.3 – 25.3	20.01 9.0 – 23.8	18.72 15.1 – 23.3	17.46 13.3 – 21.9	22.03 17.8 – 26.6
Height difference (m)	-0.75 -6.0 – 4.5	0.53 -2.4 – 3.5	1.80 -0.7 – 6.3	-2.29 -10.0 – 2.0	-1.51 -4.6 – 1.6	-1.03 -5.3 – 0.3	2.34 -2.3 – 8.0
FRI-based stocking	0.88 0.5 – 1.1	0.70 0.4 – 1.1	0.84 0.7 – 1.1	0.84 0.6 – 1.0	0.87 0.6 – 1.4	0.76 0.4 – 1.1	1.12 0.7 – 1.7
Stocking difference	-0.03 -0.4 – 0.3	-0.32 -0.9 – 0.2	-0.02 -0.3 – 0.3	0.00 -0.3 – 0.3	-0.09 -0.4 – 0.4	0.04 -0.2 – 0.3	0.00 -0.6 – 0.5

[a] one stand in MW2 was excluded from analysis due to missing FRI attributes

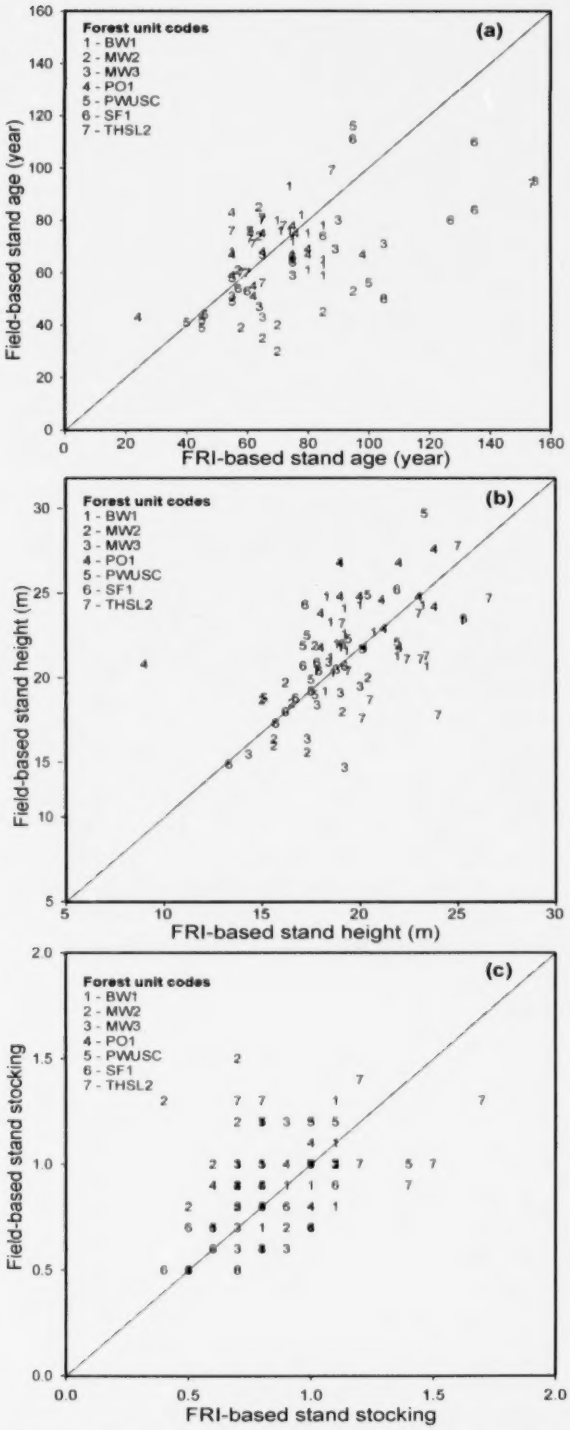

***Figure 3**. FRI- vs field-based stand attributes for seven standard forest units for: (a) stand age (year), (b) stand height (m), and (c) stand stocking. Diagonal line indicates where FRI- and field-based attributes are equal.*

mean difference between FRI- and field-based stand height for the first group of stands was -1.37 m; in other words, for a stand classified as BW1, PO1, PWUSC, or SF1 based on FRI species composition, the FRI-based stand height was on average 1.37 m lower than the field-based height. Similarly, for a stand classified as MW2, MW3, or THSL2 based on FRI species composition, the FRI-based stand height was on average 1.64 m greater than the field-based height.

Discussion

The proportion of stands classified to the same standard forest units both in FRI and in the field was 39%; for forest units with a minimum field sample size of 10 stands, the number was 42% (Table 1). Many factors may have contributed to this level of discrepancy between FRI- and field-based forest units. First, the difference between FRI- and field-based species composition for a given stand can be relatively small (e.g., 10%) but still can result in the stand being assigned to different forest units. Second, the FRI- and field-based estimates of stand species composition relied on the use of cruise lines. In the FRI, photos were interpreted visually using cruise lines established subjectively in a very limited number of selected stands. In our study, the cruise lines were established randomly in each sampled stand. Both methods may introduce additional bias when stand species composition is not homogenous. Third, species composition could have changed between the year of FRI photo production (1989) and the year of field sampling (2003). As seen from Figure 2, the agreement between FRI- and field-based classification of forest units could be higher, e.g., in the 60 to 70% range assuming a 10% change in FRI-based species composition.

The level of agreement was slightly higher for conifer stands than mixedwood and hardwoods stands. This could be interpreted as FRI being more accurate in conifer-dominated forest units (or boreal forest region) than hardwood-dominated ones (or Great Lakes - St. Lawrence region). However, a similar study to this one should be undertaken in other forests to confirm this assumption.

Although the agreement between FRI- and field-based classification into forest units seems low, it has to be examined in the context of similar studies on validating FRI-based species composition. We are aware of one comprehensive study of this type, namely, an inventory audit undertaken by the Ministry of Forests in British Columbia, Canada, in 1992-1999 (BCMF 2006). This audit was undertaken to validate the FRI information for each of BC's 37 Timber Supply Areas (TSAs, administrative units, similar to FMU in Ontario). In each TSA, mature (greater than 60-year-old) forest stands were sampled for various stands attributes including species composition; the number of sampled stands per TSA varied from 46 to 130, with most TSAs having a sample size of 50 stands. For each stand, species composition measured in the audit and available in the FRI was converted into growth type groups (growth type group is a BC-specific aggregation of forest stands, similar in concept to the planning forest units used in Ontario). The audit- and FRI-based growth type groups were cross-tabulated using the same approach as presented in Table 1.

The summary of BC audit results on classification of stands into growth type groups is presented in Appendix 4. The agreement between the audit- and FRI-based growth type groups varied by TSA, ranging from 32% to 84%, with the average agreement being 57%.

This appears higher than the 39% agreement obtained in our study, however, two factors are contributing to a higher level of agreement. First, growth type group is a broader category than standard forest unit; it is more similar to Ontario's planning forest units. Better agreement is expected for broader categories because stands are divided into fewer groups. Indeed, a similar analysis of our data based on planning forest units showed 54% agreement between FRI- and field-based classification of stands, which is very close to the BC results for mature stands. Second, species composition in young stands (less than 60 years) was evaluated in BC's audit using a separate sample, and showed a much poorer agreement (between 6 and 60%) between the audit- and FRI-based growth type groups. Overall, we can conclude that our results are within the range of values produced by BC's forest resource inventory audit. This consistency in agreement levels between our study and the BC audit emphasizes

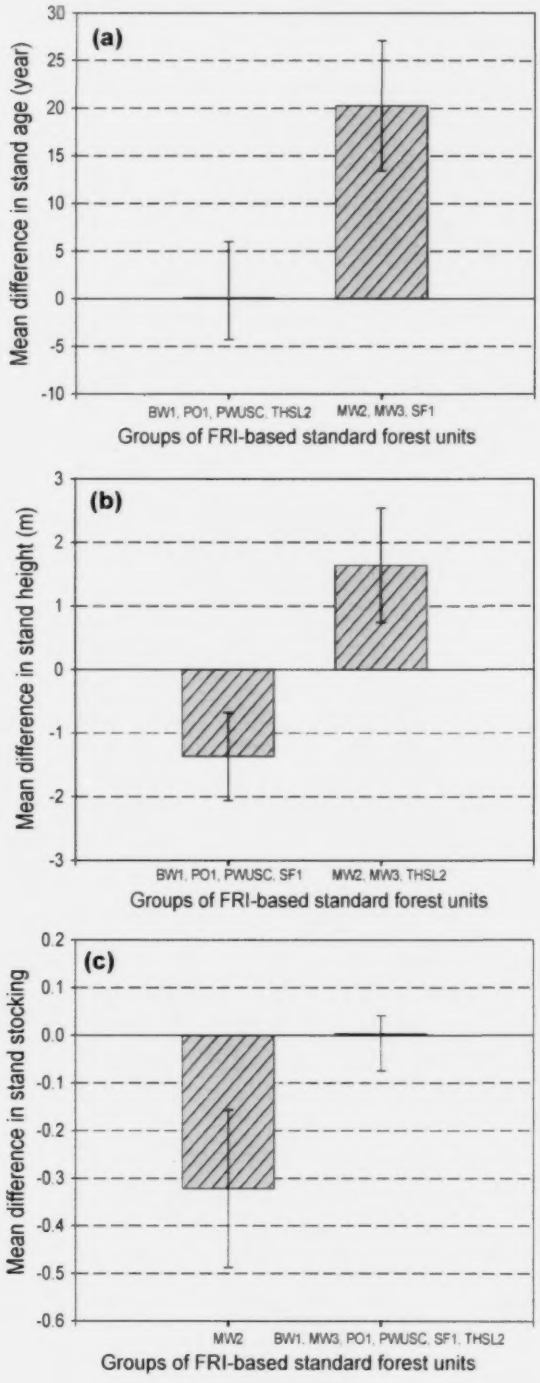

Figure 4. *Mean difference between FRI- and field-based stand attributes for groups of forest units for: (a) stand age (year), (b) stand height (m), and (c) stand stocking. Error bars show 95% confidence interval for the means.*

the challenges of assessing stand species composition using photography and possibly other imaging technology. More extensive studies on validating FRI, mainly in the boreal forest region, may be needed prior to concluding on achievable (and acceptable) level of agreement between FRI- and field-based species composition estimates.

As seen from Figure 4 and Table 3, the mean difference between FRI- and field-based age was not significantly different from zero for stands classified into one of the following four standard forest units: BW1, PO1, PWUSC, and THSL2. For stands classified into one of the remaining three standard forest units (MW2, MW3, SF1) the mean difference was equal to 20 years, i.e., FRI-based stand age was on average 20 years older than that based on field data. The difference in stand height was significantly different from zero for all forest units, with four of them (BW1, PO1, PWUSC, SF1) showing FRI-based height on average 1.37 m less than field estimates, while for the other three forest units (MW2, MW3, THSL2) FRI-based height was on average 1.64 m taller. Finally, the difference in the stand stocking was significantly different from zero for only one forest unit (MW2), with the FRI-based stocking on average 0.3 lower than the field-based one.

Table 4 presents the grouping of standard forest units for each of the three analyzed stand attributes (age, height, and stocking). For each attribute, stands classified into one group of forest units based on FRI species composition were insignificantly different in terms of the difference between FRI- and field-based estimates of the attribute; on the contrary, significant difference existed between stands classified into different groups. As seen from Table 4, MW2 was the only standard forest unit for which significant difference between FRI- and field-based attribute was detected for all three attributes. This is likely the result of forest unit classification rules: MW2 is the unit to which stands are classified upon failing to meet criteria for other forest units (Appendix 2). In other words, MW2 is a "catch-all" forest unit; stands within this unit are more diverse in terms of species composition, likely resulting in a higher variation in the estimates of stand attributes.

Unfortunately, our results for age, height, and stocking cannot be compared to the BC results. First, only one TSA report includes the comparison between FRI and audit-based height and age; other reports present only results on stand volume and species composition. Second, stand attributes in BC's audit were compared as one group, without dividing them into growth type groups. The small sample size (on average 50 stands per TSA) may have prevented further break down of the stands into sub-groups, but at the same time this may have also obscured the differences between growth type groups. For example, the difference between FRI- and field-based stand height was equal to -0.2 m when all stands in our study were pooled together. However, results for individual forest units have more application since they form the basis of forest management planning.

Table 3. *Mean difference between FRI- and field-based attributes for groups of FRI-based standard forest units.*

Attribute	Group of FRI-based standard forest units	Mean difference	0.95-confidence interval
Age (year)	BW1, PO1, PWUSC, THSL2	0	-4 to 6
	MW2, MW3, SF1	20	13 to 27
Height (m)	BW1, PO1, PWUSC, SF1	-1.37	-2.06 to -0.68
	MW2, MW3, THSL2	1.64	0.74 to 2.54
Stocking	MW2	-0.3	-0.5 to -0.2
	BW1, MW3, PO1, PWUSC, SF1, THSL2	0.0	-0.1 to 0.1

Table 4. *Grouping of FRI-based standard forest units for three stand attributes (age, height, and stocking). For each attribute, light- and dark-shaded cells represent two groups of standard forest units, respectively. The difference between FRI- and field-based attribute is insignificantly different within groups but is significantly different between groups (see Appendix 3, Table 9).*

Attribute	FRI-based standard forest units						
Age difference (year)	MW2	MW3	SF1	THSL2	BW1	PO1	PWUSC
Height difference (m)	MW2	MW3	SF1	THSL2	BW1	PO1	PWUSC
Stocking difference	MW2	MW3	SF1	THSL2	BW1	PO1	PWUSC

Conclusions

The estimates in Tables 1 and 3 indicate variable level of agreement between FRI and field-based values of several stand attributes (species composition, age, height, and stocking). These estimates provide baseline data that may be used (with additional information if needed) as an adjustment factor to the FRI-based stand attributes when assessing growing stock in the Nipissing Forest, preparing input data for timber supply modelling, estimating wildlife habitat area, and other forest management applications. The values in Tables 1 and 3 represent only the Nipissing Forest FRI and cannot be applied to other forests without similar validation studies. However, this study can be used as a template for other FRI validation studies, as a basis to recommend that a new inventory be conducted, and to prioritize re-inventory activities.

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Appendix 1. Descriptive statistics for Nipissing Forest standard forest units.

Table 5. *Descriptive statistics for Nipissing Forest standard forest units based on the FRI updated for the most recent forest management plan (Cottam and Street 2004).*

Forest unit code	Forest unit description	Weighted average species composition[a]	Average site class	Average stocking	Forest area (ha)
BW1	White birch	Bw4Po2Bf1Mh1Ms1Oh1	2.0	0.80	94135
BY1	Yellow Birch	By4Bf1Ce1He1Mh1Ms1Oh1	1.7	0.77	12607
CE1	E. White Cedar	Ce7Sb1Sw1Bf1	2.0	0.65	10849
HE1	E. Hemlock	He5By2Mh1Ms1Oh1	1.7	0.79	10083
LC1	Lowland Conifer	Sb5Oc3Bf1Ce1	1.6	0.64	7181
LWMW	Lowland Mixedwood	Ce2Oh2Sb1Bf1Bw1By1Ms1Ab1	1.7	0.77	12280
MHBE	Maple-Beech	Mh4Be2Oh2By1Ms1	1.1	0.78	2729
MHCON	Maple-Conifer	Mh3By2He2Bf1Ms1Oh1	1.5	0.79	19167
MIDHD	Midtolerant Hardwood	Mh3Oh3Or1By1Ms1Bd1	1.4	0.85	3838
MW1	Mixedwood 1	Pj4Po3Bw2Sb1	2.5	0.72	1345
MW2	Mixedwood 2	Sb3Bf2Po2Bw1Ms1Oh1	1.2	0.71	3647
MW3	Mixedwood 3	Bw2Po2Sb1Sw1Bf1Ce1Ms1Oh1	1.9	0.75	43410
OAK	Oak	Or5Po1Bw1Mh1Ms1Oh1	2.3	0.76	4928
PJ1	Jackpine 1	Pj9Sb1	2.1	0.59	11869
PJ2	Jackpine 2	Pj5Sb2Pw1Po1Bw1	2.3	0.68	5885
PO1	Poplar	Po8Bf1Bw1	2.3	0.64	47824
PR1	Red pine	Pr10	1.4	0.72	9215
PWOR	White pine Oak	Pw4Or2Pr1Po1Ms1Oh1	1.9	0.58	1668
PWST	White pine seed tree harvest	Pw10	2.0	0.00	5165
PWUS4	White pine 4-cut shelterwood	Pw6Pr1Sw1Po1Bw1	1.5	0.67	34627
PWUSC	White pine uniform shelterwood conifer	Pw3Pr1Sw1Bf1Po1Bw1Ms1Oh1	1.8	0.70	51891
SB1	Black spruce	Sb10	1.6	0.38	14317
SF1	Spruce fir 1	Sb4Sw2Bf2Bw1Ce1	1.3	0.58	26369
SF2	Spruce fir 2	Sw2Bf2Pw1Sb1Po1Bw1Ms1Oh1	1.4	0.72	69541
SP1	Spruce pine	Sb4Pj2Pw1Bf1Bw1Po1	1.4	0.70	9391
THSL1	Tolerant hardwood selection 1	Mh6By2Ms1Oh1	1.1	0.85	55104
THSL2	Tolerant hardwood selection 2	Mh5By2He1Ms1Oh1	1.1	0.78	26496
THUSG	Tolerant hardwood uniform shelterwood good site classes	Mh4Bw3Bf1By1Po1	1.4	0.88	3529
THUSP	Tolerant hardwood uniform shelterwood poor site class	Mh4By2Bw1Po1Ms1Oh1	3.0	0.74	3760

[a] Species codes: Ab – black ash; Bd – basswood; Be – American beech; Bf – balsam fir; Bw – white birch; By – yellow birch; He – eastern hemlock; Ce – eastern white cedar; La – larch (tamarack); Mh – sugar maple; Mr – red maple; Ms – silver maple; Oc – other conifer; Oh – other hardwoods; Or – red oak; Po – poplar (trembling aspen); Pj – jack pine; Pr – red pine; Pw – eastern white pine; Sb – black spruce; Sw – white spruce.

Appendix 2. Classification rules for standard forest units in central Ontario

Table 6. *Classification rules for standard forest units in central Ontario. Species codes are listed in the footnote to Table 5. To classify a stand into one of the standard forest units, the following rules are applied in sequential order (starting from 1) until the condition for species composition (and if required, other stand attributes) is met.*

Rule (#)	Forest unit code	Classification rule
1	PR1	(PR>=70) AND (PW<30)
2	PWUS4	(PW+PR>=50) AND (PW>PR) AND ((PW+PR)*STK >=30) AND ([OR]+OW <20))
3	PWOR	(PW+PR+[OR]+OW>=50) AND (PW>=([OR]+OW)) AND ((PW+PR+[OR]+OW)*STK >=30) AND ([OR]+OW>=20)
4	PWUSC	((PW+PR>=30) AND ((PW+PR)*STK >=30)) OR ((PW>=HE) AND (PW>=SW) AND (PW>CE) AND (PW>=[OR]) AND (PW+PR >=30) AND ((PW+PR+SW+HE+[OR]+PJ+CE)*STK >=30)) AND ((PW+PR+PJ+SW+SB+HE+BF+CE+LA)>=80)
5	PWUSH	((PW>=PR) AND (PW+PR>=30) AND ((PW+PR)*STK >=30))) OR ((PW>=PR) AND (PW>=HE) AND (PW>=SW) AND (PW>CE) AND (PW>=[OR]) AND (PW+PR >=30) AND ((PW+PR+SW+HE+[OR]+PJ+CE)*STK >=30)) AND ((PW+PR+PJ+SW+SB+HE+BF+CE+LA)<80)
6	PWST	(PW+PR>=30) AND (PW+PR>=HE) AND (PW+PR>=SW) AND (PW+PR>=SB) AND (PW+PR>=CE) AND (PW+PR>=[OR])
7	PJ1	(PJ>=70) AND (MH+AB+AW+BD+BE+CH+EW+IW+[OR]+BY+OW+PO+BW+MS<=20)
8	PJ2	((PJ+SB+PR>=70) OR (((PJ>=50) AND (PJ+SB+BF+SW+HE+PW+PR+CE+LA>=70) AND (BF+SW+HE+PW+CE+LA<=20)) AND (PJ>=SB))
9	HE1	HE>=40
10	CE1	(CE>=40) AND (CE>=SB+LA+BF) AND (MH+AB+AW+BD+BE+CH+EW+IW+[OR]+BY+OW+PO+BW+MS<30)
11	SB1	(SB>=80) AND (MH+AW+BD+BE+CH+IW+[OR]+OW+BY+PR=0) AND (PW+PJ<=10)
12	LC1	(SB+CE+LA>=80) AND (MH+AW+BD+BE+CH+IW+[OR]+OW+BY+PR=0) AND (PW+PJ <=10)
13	SP1	(SB+SW+BF+CE+LA+PW+PJ+PR+HE>=70) AND ((BF+CE+PW+LA+SW+HE<=20) OR (PJ>=30))
14	SF2	((SW+PW+PR+BF)>=40) AND ((SW+PW+PR)*STK>=30)
15	SF1	(SW+SB+PW+PR+PJ+BF+CE+LA+HE)>=70
16	BY1	BY>=40
17	OAK	([OR]>=MH+BE) AND ([OR]>=30) AND ([OR]+MH+AW+AB+BE+BD+BY+PW+PR+SW+HE>=40)
18	MIDHD	BD+AW+CH+[OR]+OW>=30
19	MHBE	(BE+[OR]+OW>=30) OR (BE>=20)
20	MHCON	((MH+AW+BD+BE+CH+EW+IW+[OR]+BY+OW+HE)>=50) AND ((SW+SB+PW+PR+PJ+BF+CE+LA+HE)>=30) AND ((SC = 'X') OR (SC = '1') OR (SC = '2')) AND (AGE>=80) AND (STK>=0.6)
21	THSL1	(MH+AW+BD+BE+CH+EW+IW+[OR]+BY+OW+HE>=50) AND (PO+BW+BF<=30) AND ((SC = 'X') OR (SC = '1') OR (SC = '2')) AND (AGE>=80) AND (STK>=0.6)
22	THSL2	(MH+AW+BD+BE+CH+EW+IW+[OR]+BY+OW+HE>=50) AND (PO+BW+BF<=30) AND ((SC = 'X') OR (SC = '1') OR (SC = '2'))
23	LWMW	(CE+AB+LA+SB>=30) AND ((AB>=20) OR (AB+MS+BY>=30))
24	THUSP	(MH+AW+BD+BE+CH+EW+IW+[OR]+BY+OW+HE>=50) AND (SC = '3')
25	THUSG	(MH+AW+BD+BE+CH+EW+IW+[OR]+BY+OW+HE>=50) AND ((SC = 'X') OR (SC = '1') OR (SC = '2'))
26	PO1	(PO>=50) AND (MH+AB+AW+BD+BE+CH+EW+IW+[OR]+BY+OW+PO+BW+MS>=70)
27	BW1	BW + PO >= 50
28	MW3	(SW+PW+PR+CE+MH+BY+AW+CH+BD+[OR]+OW+IW+BE+HE)*STK>=30
29	MW1	PJ+PW+PR>=20
30	MW2	DEFAULT (all remaining stands)

Appendix 3. Analysis of differences between FRI- and field-based age, height, and stocking

Included in the data analysis were stands representing the following FRI-based standard forest units: BW1, MW2, MW3, PO1, PWUSC, SF1, and THSL2 (see Appendix 1 for description) with a minimum sample size of 10 stands. One stand representing standard forest unit MW2 was excluded from the analysis because of missing FRI-based attributes, reducing the sample size for this unit to 9.

1. First, we calculated the difference between the FRI- and field-based attribute for each stand and tested these differences for correlation among attributes (Table 7). This test was undertaken to ensure a lack of "synchrony" among attribute differences. An example of synchrony would be a simultaneous increase in difference between FRI- and field-based age and height, respectively, as the stand age increases.

As seen from Table 7, correlation was weak between differences in stand age and stocking, and almost non-existent between differences in stand age and height, and stand height and stocking, respectively. Therefore, further analysis was performed separately for each of the three stand attributes. (Note: If correlation between any pair of attributes were high, the following approaches could be considered: (a) perform analysis for one attribute and "project" the results on to other attribute(s) using preliminarily fitted regression equations of the latter attribute(s) on the former one, or (b) perform multivariate analysis for correlated attributes.)

2. For each stand attribute, we used linear regression analysis to test for a systematic pattern of differences between FRI- and field-based values of the attribute. Such pattern may occur if the difference between FRI- and field-based attribute increases (or decreases) as the FRI-based value of the attribute increases (e.g., the older the stand, the greater the difference between FRI- and field-based age estimates). Regression analysis was applied separately to each standard forest unit. In other words, the field-based stand age was regressed on FRI-based stand age for stands representing FRI-based unit BW1, and so on.

Regression equations were fitted to a total of 21 stand attribute-standard forest unit combinations (3 attributes x 7 standard forest units). For fourteen of these combinations, regression was not significant, with P values ranging from 0.063 to 0.802. Further examination of the remaining 7 combinations revealed that:

(a) regression slope was insignificantly different from 1.0 for 4 attribute-stand forest unit combinations. This test was conducted by fitting a linear regression with the slope fixed at 1.0, and then comparing the sum of squared residuals with those of a full linear regression (both intercept and slope fitted to the data).

(b) regression for three attribute-stand forest unit combinations was highly influenced by high leverage data points (e.g., one data point far away from a cluster of the rest of data points). The regression was non-significant one following removal of these data points.

The above results suggested that for each forest unit and for each stand attribute, the difference between the FRI- and field-based attribute was not related to the value of the FRI-based attribute. Therefore, our further analysis was focused on the mean difference between FRI- and field-based attributes.

We did not attempt the use of non-linear regression analysis because of the small sample size per

Table 7. *Pearson correlation coefficients among differences between FRI- and field-based stand attributes (sample size 83).*

	Age (year)	Height (m)	Stocking
Height (m)	0.182	1.000	-
Stocking	-0.345	0.174	1.000

standard forest unit and, more important, lack of non-empirical evidence suggesting a non-linear relationship between FRI- and field-based values of the attribute. Where scatterplots of FRI- versus field-based values of the attribute exhibit strong signs of non-linearity, it may be better to divide the data into sub-groups (e.g., young and mature stands) and analyze it separately for each group (provided sufficient sample size).

3. For each attribute, the mean difference between FRI- and field-based values was tested for significant differences among standard forest units using one-factor ANOVA, i.e., the null hypothesis was that the means are equal among standard forest units. This hypothesis was rejected for each stand attribute, with P-values of 0.0029 for age difference, 0.0001 for height difference, and 0.0454 for stocking difference.

4. For each attribute, a multiple comparisons test was used to separate standard forest units into groups within which the mean difference between FRI- and field-based values was not significantly different. We used Newman-Keuls test because it is more powerful at detecting significant differences than Tukey's test, which is commonly offered in statistical packages (Zar 1996). The test requires ranking standard forest units in descending order of the mean difference in tested attribute, and then comparing the forest unit with largest mean against the forest unit with smallest mean, then the group with largest mean against the group with second smallest mean, and so on.

Table 8 demonstrates the testing sequence for the difference between FRI- and field-based stand height (shortly, mean height difference). In the first step, the units are ranked in descending order of mean height difference (from THSL2 to PO1). The following steps include pair-wise comparison of standard forest units, at each step the null hypothesis H_0 being that the mean height difference is equal between the two compared forest units. The procedure requires that the unit

Table 8. *Multiple comparisons of mean height difference among the seven standard forest units.*

Step 1	Ranking of standard forest units in descending order of mean height difference (m)						
	THSL2	MW3	MW2	BW1	SF1	PWUSC	PO1
	2.34	1.80	0.53	-0.75	-1.03	-1.51	-2.29
Step 2	H_0: mean height difference is equal between THSL2 and PO1 P-value < 0.001 reject H_0						
Step 3	H_0: mean height difference is equal between THSL2 and PWUSC P-value = 0.007 reject H_0						
Step 4	H_0: mean height difference is equal between THSL2 and SF1 P-value = 0.015 reject H_0						
Step 5	H_0: mean height difference is equal between THSL2 and BW1 P-value = 0.008 reject H_0						
Step 6	H_0: mean height difference is equal between THSL2 and MW2 P-value = 0.236 accept H_0						
Step 7	H_0: mean height difference is equal between MW3 and PO1 P-value = 0.002 reject H_0						
Step 8	H_0: mean height difference is equal between MW3 and PWUSC P-value = 0.032 reject H_0						
Step 9	H_0: mean height difference is equal between MW3 and SF1 P-value = 0.045 reject H_0						
Step 10	H_0: mean height difference is equal between MW3 and BW1 P-value = 0.033 reject H_0						
Step 11	H_0: mean height difference is equal between MW3 and MW2 P-value = 0.274 accept H_0						
Step 12	H_0: mean height difference is equal between MW2 and PO1 P-value = 0.074 accept H_0						

with the largest mean (THSL2) is compared with the one with the smallest mean (PO1), then the largest (THSL2) against the second smallest (PWUSC), and so on until H_0 is accepted. Then the unit with second largest mean (MW3) is compared against the unit with the smallest mean (PO1). The procedure stops once it reaches a pair that (a) is not significantly different in terms of the mean height difference, and (b) one of the units in this pair is the one with the smallest mean height difference.

The results in Table 8 distinguish two groups of forest units: [THSL2, MW3] and [BW1, SF1, PWUSC, PO1], with all pair-wise comparisons of cross-group units yielding significantly different mean height difference. However, the results are ambiguous for forest unit MW2 since it appears to be not significantly different from either the first group (steps 6 and 11) or the second one (step 12). Such ambiguity is common in multiple comparison tests (Zar 1996) and requires further testing to assign MW2 to one of the two groups.

Similar results were produced in multiple comparisons among standard forest units for mean age difference. The tests distinguished two groups of significantly different forest units ([MW3] and [BW1, PO1, PWUSC, THSL2]) but were inconclusive for MW2 and SF1. However, multiple comparisons among standard forest units for mean stocking difference separated all units into two groups: [BW1, MW3, PO1, PWUSC, SF1, THSL2] and [MW2].

5. Sheffé's multiple contrasts test was used to complete the analysis for mean stand height and age differences. For mean stand height difference, we tested two hypotheses:

a) The mean height difference in standard forest units THSL2 and MW3 is insignificantly different from the mean height difference in standard forest unit MW2. A mathematical expression for this hypothesis is $(HtD_{THSL2} + HtD_{MW3})/2 - HtD_{MW2} = 0$ where HtD_{THSL2}, HtD_{MW3}, and HtD_{MW2} are mean height difference in stands representing standard forest units THSL2, MW3, and MW2, respectively. This hypothesis was accepted (P-value = 0.949)

b) The mean height difference in standard forest units THSL2, MW3, and MW2 is insignificantly different from the mean height difference in standard forest units BW1, SF1, PWUSC, PO1. This hypothesis was rejected (P-value = 0.0007).

Based on the above two tests, we concluded that for estimating mean stand height, the stands representing standard forest units MW2 can be combined with those representing units THSL2 and MW3, producing the split in forest units presented in Table 4.

Similarly, two hypotheses were tested for mean age difference, namely:

c) The mean age difference in standard forest unit MW3 is insignificantly different from the mean age difference in standard forest units MW2 and SF1. This hypothesis was accepted, with a P-value of 0.998.

d) The mean age difference in standard forest units MW2, MW3, and SF1 is insignificantly different from the mean age difference in standard forest units BW1, PWUSC, PO1, and THSL2. This hypothesis was rejected (P-value = 0.005).

Therefore to estimate mean stand age difference, stands representing standard forest units MW2, MW3, and SF1 were pooled together resulting in the grouping of standard forest units presented in Table 4.

6. The 95%-confidence intervals for mean difference in each stand attribute were estimated (Table 3) for each group of standard forest units following multiple comparisons tests described in steps 5 and 6. The intervals were rounded to the same decimal place as appeared in the original FRI and field data. The formulae used to estimate these intervals account for all standard forest units included in multiple comparisons test, and thus differ slightly from those estimated individually for each group (Zar 1996).

7. For each stand attribute, data for each group of standard forest units (see Table 4) were pooled together and the mean difference for this attribute was calculated using all stands in this group. This mean was tested for significance of difference from zero using one-sample t-test. Results are presented in Table 9 below. For two stand attribute-group of standard forest unit combinations, the mean difference between the FRI- and field-based value of the attribute was insignificantly different from zero (mean age

difference for BW1, PO1, PWUSC, THSL2, and mean stocking difference for BW1, MW3, PO1, PWUSC, SF1, THSL2). Therefore mean differences for these attributes-groups of standard forest units are reported in Table 3 as having a zero value. Confidence intervals for these mean differences were calculated for actual mean values and therefore appear de-centred around the means reported in Table 3. For other tested stand attribute-groups of standard forest unit combinations, mean differences were significantly different from zero and therefore are presented in Table 3 of the main text as calculated.

Table 9. *Tests for significance of difference from zero of mean difference in stand attribute for groups of stands representing standard forest units summarized in Table 4.*

Stand attribute	Group of standard forest units	Mean difference between FRI- and field-based value of the attribute	Significance of difference from zero (P-value)
Age (year)	BW1, PO1, PWUSC, THSL2	0.85	0.704
	MW2, MW3, SF1	20.27	< 0.001
Height (m)	BW1, PO1, PWUSC, SF1	-1.37	< 0.001
	MW2, MW3, THSL2	1.64	< 0.001
Stocking	MW2	-0.32	0.032
	BW1, MW3, PO1, PWUSC, SF1, THSL2	-0.02	0.537

Appendix 4. Summary of British Columbia's audit on classification of stands into growth type groups

Table 10. *Number of sampled stands (mature and immature) and level of agreement between FRI- and field-based classification of stand species composition into growth type groups. Numbers are compiled from audit reports posted on British Columbia Ministry of Forests website (BCMF 2006).*

Timber Supply Area (TSA)	Mature stands (>60 years of age)		Immature stands (<60 years of age)	
	Sampled stands (#)	Agreement (%)	Sampled stands (#)	Agreement (%)
100 Mile House	50	52	-	-
Arrow	50	44	-	-
Arrowsmith	50	68	-	-
Boundary	-	-	-	-
Bulkley	50	74	19	26
Cassiar	-	-	20	45
Clearwater District	-	-	-	-
Cranberry	40	60	-	-
Cranbrook	50	48	-	-
Dawson Creek	50	32	19	42
Fort St. John	49	33	20	45
Fraser	46	74	19	47
Golden	50	36	20	35
Invermere	-	-	-	-
Kalum	50	60	20	45
Kamloops District	50	40	18	6
Kingcome	50	84	20	35
Kispiox	50	68	20	35
Kootenay Lake	40	45	17	41
Lakes	50	52	20	60
Lillooet	50	54	20	26
Mackenzie	-	-	-	-
Merritt	50	62	20	55
Midcoast	49	63	18	50
Morice	50	62	20	60
Nass	-	-	20	26
North Coast	49	51	20	39
Okanagan	50	48	19	37
Prince George	130	52	39	44
Queen Charlotte Islands	67	61	-	-
Quesnel	51	67	-	-
Robson Valley	49	57	20	35
Soo	47	49	20	40
Strathcona	50	62	20	30
Upper Nass	-	-	-	-
Williams Lake	124	73	-	-
Total	**1591**	**56.9**	**468**	**39.6**

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